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```
FinalPrep.m --- ELEC 403 Final exam, this matlab file is used to do the
various problems in the ELEC 403 textbook that are related to the final
exam, of course the focus is on chapter 5 and chapter 7.
```

Prob 5.2 with jacobian f(x) = x^2+2*y^2+4*x +4*y

- REMEMBER THAT CHAPTER 5 only has SDM, Newton and Gauss-Newton*

```
syms x_1 x_2
f = x_1^2+2*x_2^2+4*x_1+4*x_2;
latex(f);
g=gradient(f);
latex(g);
f1 = x_1+2;
f2 = sqrt(2)*(x_2+1);
j=jacobian([f1,f2],[x_1,x_2]);
h = hessian(f);
%steep_desc3('func52','grad52',[-1; 1],1e-3);
gauss_newton('func52','grad52','jacob52',[-1; 1],1e-3);


Program gauss_newton.m
------- ITERATION 1 ------
STEP 1

xk =

    -1
     1

STEP 2

F_k =
```

```
     3

STEP 3

gk =

     2
     8


Jk =

    1.0000         0
         0    1.4142


Hk =

    2.0000         0
         0    4.0000

STEP 4

dk =

   -1.0000
   -2.0000

STEP 5

ak =

    1.0000

STEP 6

adk =

   -1.0000
   -2.0000


er =

    2.2361

STEP 6

xk =

   -2.0000
   -1.0000
```

```
F_k1 =

    -6

------- ITERATION 2 ------
STEP 3

gk =

   1.0e-12 *

    0.4450
   -0.2185


Jk =

    1.0000         0
         0    1.4142


Hk =

    2.0000         0
         0    4.0000

STEP 4

dk =

   1.0e-12 *

   -0.2225
    0.0546

STEP 5

ak =

     1


adk =

   1.0e-12 *

   -0.2225
    0.0546


er =

     9
```

```
STEP 6

xk =

    -2
    -1


F_k1 =

    -6

------- ITERATION 3 ------
STEP 3

gk =

     0
     0


Jk =

    1.0000         0
         0    1.4142


Hk =

    2.0000         0
         0    4.0000

STEP 4

dk =

     0
     0

STEP 5

ak =

     1


adk =

     0
     0


er =
```

```
     0

Solution point:

xs =

    -2
    -1

Objective function at the solution point:

fs =

    -6

Number of iterations performed:

k =

     3
```

Prob 5.2 with Newton

```
newton('func52','grad52','hess52',[0; 0],0.1,1e-3);


Program newton.m
------- ITERATION 1 ------
STEP 1

xk =

     0
     0

STEP 2

gk =

     4
     4


Hk =

     2     0
     0     4

STEP 3

dk =
```

```
    -2
    -1

STEP 4
Alpha: 1.000000000

er =

    2.2361

STEP 5

xk =

    -2
    -1

------- ITERATION 2 ------
STEP 2

gk =

     0
     0


Hk =

     2     0
     0     4

STEP 3

Hki =

    0.5000         0
         0    0.2500


dk =

     0
     0

STEP 4
Alpha: 1.000000000
STEP 5

adk =

     0
     0
```

```
Solution point:

xs =

    -2
    -1

Objective function at the solution point:

fs =

    -6

Number of iterations performed:

k =

     2
```

Prob 5.4 -- Find a good starting point besides x0 = [1 1]

```
syms x_1 x_2
f = 5*x_1^2-9*x_1*x_2+4.075*x_2^2+x_1;
latex(f);
g = gradient(f);
latex(g);
steep_desc3('func54','grad54',[-16; -17.9],1e-3);
h = hessian(f);


Program steep_desc3.m
------- ITERATION 1 ------
STEP 1

xk =

  -16.0000
  -17.9000

STEP 2

gk =

    2.1000
   -1.8850


dk =

   -2.1000
```

```
    1.8850

STEP 3
Alpha: 0.055180698
STEP 4
  xk+1: -16.115879466
  xk+1: -17.795984384
f(xk) = -8.148958e+00


xk =

  -16.1159
  -17.7960

------- ITERATION 2 ------
STEP 2

gk =

    0.0051
    0.0056


dk =

   -0.0051
   -0.0056

STEP 3
Alpha: 36.073499423
STEP 4

xk =

  -16.2986
  -17.9995

------- ITERATION 3 ------
STEP 2

gk =

    0.0099
   -0.0089


dk =

   -0.0099
    0.0089

STEP 3
Alpha: 0.055180697
```

```
STEP 4
Solution point:

xs =

 -16.299131032840879
 -17.999037136909219

Objective function at the solution point:

fs =

  -8.149999976794053

Number of iterations performed:

k =

     3
```

5.4 Using Newton

```
h = hessian(f);
latex(h)
newton('func54','grad54','hess54',[-10; -5],0.1,1e-6);


ans =

\left(\begin{array}{cc} 10 & -9\\ -9 & \frac{163}{20}
 \end{array}\right)


Program newton.m
------- ITERATION 1 ------
STEP 1

xk =

   -10
    -5

STEP 2

gk =

  -54.0000
   49.2500


Hk =
```

```
   10.0000   -9.0000
   -9.0000    8.1500

STEP 3

dk =

   -6.3000
  -13.0000

STEP 4
Alpha: 0.945675721

er =

   13.6613

STEP 5

xk =

  -15.9578
  -17.2938

------- ITERATION 2 ------
STEP 2

gk =

   -2.9335
    2.6755


Hk =

   10.0000   -9.0000
   -9.0000    8.1500

STEP 3

Hki =

   16.3000   18.0000
   18.0000   20.0000


dk =

   -0.3422
   -0.7062

STEP 4
Alpha: 1.000000000
STEP 5
```

```
adk =

   -0.3422
   -0.7062


xk =

  -16.3000
  -18.0000

------- ITERATION 3 ------
STEP 2

gk =

   1.0e-13 *

    0.5684
   -0.5684


Hk =

   10.0000   -9.0000
   -9.0000    8.1500

STEP 3

Hki =

   16.3000   18.0000
   18.0000   20.0000


dk =

   1.0e-12 *

    0.0966
    0.1137

STEP 4
Alpha: 1.000000000
STEP 5

adk =

   1.0e-12 *

    0.0966
    0.1137
```

```
Solution point:

xs =

 -16.300000000000054
 -18.000000000000060

Objective function at the solution point:

fs =

  -8.149999999999963

Number of iterations performed:

k =

     3
```

5.4 Using Gauss Newton

```
j = jacobian(f,[x_1,x_2]);
gauss_newton('func54','grad54','jacob54',[-16; -18],1e-3);


Program gauss_newton.m
------- ITERATION 1 ------
STEP 1

xk =

   -16
   -18

STEP 2

F_k =

   -7.7000

STEP 3

gk =

    3.0000
   -2.7000


Jk =

    3.0000   -2.7000
```

```
Hk =

   18.0000  -16.2000
  -16.2000   14.5800

STEP 4

dk =

   -0.0920
    0.0828

STEP 5

ak =

    1.7993

STEP 6

adk =

   -0.1656
    0.1489


er =

    0.2227

STEP 6

xk =

  -16.1656
  -17.8511


F_k1 =

   -8.1494

------- ITERATION 2 ------
STEP 3

gk =

    0.0037
    0.0041


Jk =
```

```
    0.0037    0.0041


Hk =

   1.0e-04 *

    0.2739    0.3046
    0.3046    0.3387

STEP 4

dk =

  -60.4078
  -67.1792

STEP 5

ak =

    0.0022


adk =

   -0.1338
   -0.1488


er =

    0.4494

STEP 6

xk =

  -16.2994
  -17.9999


F_k1 =

   -8.1500

------- ITERATION 3 ------
STEP 3

gk =

    0.0049
   -0.0044
```

```
Jk =

    0.0049   -0.0044


Hk =

   1.0e-04 *

    0.4772   -0.4291
   -0.4291    0.3859

STEP 4

dk =

  -56.5957
   50.8910

STEP 5

ak =

   1.0000e-05


adk =

   1.0e-03 *

   -0.5660
    0.5089


er =

   5.5388e-04

Solution point:

xs =

 -16.300007501945657
 -17.999413346528229

Objective function at the solution point:

fs =

  -8.149998557647706

Number of iterations performed:
```

```
k =

     3
```

Prob 5.5 -- use a closer point so that it can be done manually

Produce the latex needed for final exam review document

```
syms x_1 x_2 x_3
f = (x_1+5)^2+(x_2+8)^2+(x_3+7)^2+2*x_1^2*x_2^2+4*x_1^2*x_3^2;
latex(f)
g = gradient(f);
latex(g)

steep_desc3('func55','grad55',[0; -8; -7],1e-3)


ans =

2\, {x_{1}}^2\, {x_{2}}^2 + 4\, {x_{1}}^2\, {x_{3}}^2 + {\left(x_{1} +
 5\right)}^2 + {\left(x_{2} + 8\right)}^2 + {\left(x_{3} + 7\right)}^2


ans =

\left(\begin{array}{c} 4\, x_{1}\, {x_{2}}^2 + 8\, x_{1}\, {x_{3}}^2 +
 2\, x_{1} + 10\\ 4\, x_{2}\, {x_{1}}^2 + 2\, x_{2} + 16\\ 8\, x_{3}\,
 {x_{1}}^2 + 2\, x_{3} + 14 \end{array}\right)


Program steep_desc3.m
------- ITERATION 1 ------
STEP 1

xk =

     0
    -8
    -7

STEP 2

gk =

    10
     0
     0


dk =
```

```
   -10
     0
     0

STEP 3
Alpha: 0.001538462
STEP 4
  xk+1: -0.015384615
  xk+1: -8.000000000
  xk+1: -7.000000000
f(xk) = 2.492308e+01


xk =

   -0.0154
   -8.0000
   -7.0000

------- ITERATION 2 ------
STEP 2

gk =

   -0.0000
   -0.0076
   -0.0133


dk =

    0.0000
    0.0076
    0.0133

STEP 3
Alpha: 0.499585233
STEP 4

xk =

   -0.0154
   -7.9962
   -6.9934

------- ITERATION 3 ------
STEP 2

gk =

    0.0151
   -0.0000
    0.0000
```

```
dk =

   -0.0151
    0.0000
   -0.0000

STEP 3
Alpha: 0.001540793
STEP 4
Solution point:

xs =

  -0.015407926169005
  -7.996216155022361
  -6.993378280948492

Objective function at the solution point:

fs =

  24.923018533805848

Number of iterations performed:

k =

     3


ans =

   -0.0154
   -7.9962
   -6.9934
```

Chapter 7, using Prob 5.2 with DFP

- REMEMBER THAT CHAPTER 7 only has DFP and BFGS*
- DFP
- BFGS

```
dfp('func52','grad52',[-1; 1],1e-6);


Program dfp.m
------- ITERATION 1 ------
STEP 1

xk =
```

```
    -1
     1


Sk =

     1     0
     0     1


gk =

     2
     8

STEP 2

dk =

    -2
    -8


ak =

    0.2576


dtk =

   -0.5152
   -2.0606


xk_new =

   -1.5152
   -1.0606

STEP 3
Norm of delta is 8.76 and epsi is 1.000000e-06
STEP 4

gk_new =

    0.9697
   -0.2424


gmk =

   -1.0303
   -8.2424
```

```
sg =

   -1.0303
   -8.2424


sw1 =

    0.2654    1.0615
    1.0615    4.2461


sw2 =

    1.0615    8.4922
    8.4922   67.9376


sw3 =

   68.9991


Sk =

    0.9998   -0.0625
   -0.0625    0.2578


gk =

    0.9697
   -0.2424

------- ITERATION 2 ------
STEP 2

xk =

   -1.5152
   -1.0606


dk =

   -0.9846
    0.1231


ak =

    0.4924
```

```
dtk =

   -0.4848
    0.0606

STEP 3
Norm of delta is 0.49 and epsi is 1.000000e-06
STEP 4

gk_new =

     0
     0


gmk =

   -0.9697
    0.2424


sg =

   -0.9846
    0.1231


sw1 =

    0.2351   -0.0294
   -0.0294    0.0037


sw2 =

    0.9695   -0.1212
   -0.1212    0.0151


sw3 =

    0.9846


Sk =

    0.5000   -0.0000
   -0.0000    0.2500


gk =
```

```
     0
     0

------- ITERATION 3 ------
STEP 2

xk =

    -2
    -1


dk =

     0
     0


ak =

     1


dtk =

     0
     0

STEP 3
Norm of delta is 0.00 and epsi is 1.000000e-06
solution point:

xs =

    -2
    -1

objective function at the solution point:

fs =

    -6

number of iterations at convergence:

k =

     3
```

Chapter 7, using Prob 5.2 with BFGS

```
bfgs('func52','grad52',[-1; 1],1e-6);
```

```
Program bfgs.m
------- ITERATION 1 ------
STEP 1

xk =

    -1
     1


Sk =

     1     0
     0     1


gk =

     2
     8

STEP 2

dk =

    -2
    -8


ak =

    0.2576


dtk =

   -0.5152
   -2.0606


xk_new =

   -1.5152
   -1.0606

STEP 3
Norm of delta is 8.76 and epsi is 1.000000e-06
STEP 4

gk_new =

    0.9697
   -0.2424
```

```
gmk =

   -1.0303
   -8.2424


D =

   17.5152


sg =

   -1.0303
   -8.2424


sw1 =

    0.2654    1.0615
    1.0615    4.2461


sw2 =

    0.5308    2.1230
    4.2461   16.9844


Sk =

    1.0142   -0.0643
   -0.0643    0.2580


fk =

   -5.7576


gk =

    0.9697
   -0.2424

------- Iteration 2 ------
STEP 2

dk =

   -0.9991
    0.1249
```

```
ak =

    0.4853


dtk =

   -0.4848
    0.0606

STEP 3
Norm of delta is 0.49 and epsi is 1.000000e-06
STEP 4

gk_new =

     0
     0


gmk =

   -0.9697
    0.2424


D =

    0.4848


sg =

   -0.9991
    0.1249


sw1 =

    0.2351   -0.0294
   -0.0294    0.0037


sw2 =

    0.4844   -0.0606
   -0.0606    0.0076


Sk =

    0.5000    0.0000
```

```
    0.0000    0.2500


fk =

    -6


gk =

     0
     0

------- Iteration 3 ------
STEP 2

dk =

     0
     0


ak =

     1


dtk =

     0
     0

STEP 3
Norm of delta is 0.00 and epsi is 1.000000e-06
solution point:

xs =

    -2
    -1

objective function at the solution point:

fs =

    -6

number of iterations at convergence:

k =

     3
```

Examples from the Internet --- Using DFP

$$f(x) = -2 * x_1^2 - 10 * x_2^2$$

```
dfp('funcNet1','gradNet1',[1; -1],1e-3);


Program dfp.m
------- ITERATION 1 ------
STEP 1

xk =

     1
    -1


Sk =

     1     0
     0     1


gk =

     4
   -20

STEP 2

dk =

    -4
    20


ak =

    0.0577


dtk =

   -0.2308
    1.1538


xk_new =

    0.7692
    0.1538

STEP 3
```

```
Norm of delta is 10.58 and epsi is 1.000000e-03
STEP 4

gk_new =

    3.0769
    3.0769


gmk =

   -0.9231
   23.0769


sg =

   -0.9231
   23.0769


sw1 =

    0.0533   -0.2663
   -0.2663    1.3314


sw2 =

    0.8521  -21.3018
  -21.3018  532.5444


sw3 =

  533.3964


Sk =

    1.0004    0.0300
    0.0300    0.0512


gk =

    3.0769
    3.0769

------- ITERATION 2 ------
STEP 2

xk =
```

```
    0.7692
    0.1538


dk =

   -3.1705
   -0.2499


ak =

    0.2699


dtk =

   -0.8556
   -0.0674

STEP 3
Norm of delta is 1.33 and epsi is 1.000000e-03
STEP 4

gk_new =

   -0.3456
    1.7281


gmk =

   -3.4225
   -1.3488


sg =

   -3.4644
   -0.1718


sw1 =

    0.7321    0.0577
    0.0577    0.0045


sw2 =

   12.0017    0.5951
    0.5951    0.0295
```

```
sw3 =

   12.0886


Sk =

    0.2500   -0.0001
   -0.0001    0.0503


gk =

   -0.3456
    1.7281

------- ITERATION 3 ------
STEP 2

xk =

   -0.0864
    0.0864


dk =

    0.0866
   -0.0869


ak =

    0.9949


dtk =

    0.0862
   -0.0865

STEP 3
Norm of delta is 0.12 and epsi is 1.000000e-03
STEP 4

gk_new =

   1.0e-03 *

   -0.9953
   -0.9953


gmk =
```

```
    0.3446
   -1.7291


sg =

    0.0864
   -0.0870


sw1 =

    0.0074   -0.0074
   -0.0074    0.0075


sw2 =

    0.0075   -0.0075
   -0.0075    0.0076


sw3 =

    0.1801


Sk =

    0.2501    0.0000
    0.0000    0.0500


gk =

   1.0e-03 *

   -0.9953
   -0.9953

------- ITERATION 4 ------
STEP 2

xk =

   1.0e-03 *

   -0.2488
   -0.0498


dk =
```

```
   1.0e-03 *

    0.2489
    0.0498


ak =

    0.9997


dtk =

   1.0e-03 *

    0.2488
    0.0498

STEP 3
Norm of delta is 0.00 and epsi is 1.000000e-03
solution point:

xs =

   1.0e-10 *

   0.458617078233185
  -0.458617078910812

objective function at the solution point:

fs =

     2.523955499581143e-20

number of iterations at convergence:

k =

     4
```

USING BFGS

```
bfgs('funcNet1','gradNet1',[-1; 1],1e-6);


Program bfgs.m
------- ITERATION 1 ------
STEP 1

xk =
```

```
    -1
     1


Sk =

     1     0
     0     1


gk =

    -4
    20

STEP 2

dk =

     4
   -20


ak =

    0.0577


dtk =

    0.2308
   -1.1538


xk_new =

   -0.7692
   -0.1538

STEP 3
Norm of delta is 10.58 and epsi is 1.000000e-06
STEP 4

gk_new =

   -3.0769
   -3.0769


gmk =

    0.9231
  -23.0769
```

```
D =

   26.8402


sg =

    0.9231
  -23.0769


sw1 =

    0.0533   -0.2663
   -0.2663    1.3314


sw2 =

    0.2130   -1.0651
   -5.3254   26.6272


Sk =

    1.0255    0.0310
    0.0310    0.0512


fk =

    1.4201


gk =

   -3.0769
   -3.0769

------- Iteration 2 ------
STEP 2

dk =

    3.2510
    0.2531


ak =

    0.2634
```

```
dtk =

    0.8564
    0.0667

STEP 3
Norm of delta is 1.33 and epsi is 1.000000e-06
STEP 4

gk_new =

    0.3487
   -1.7434


gmk =

    3.4256
    1.3336


D =

    3.0226


sg =

    3.5545
    0.1746


sw1 =

    0.7334    0.0571
    0.0571    0.0044


sw2 =

    3.0440    0.2370
    0.1495    0.0116


Sk =

    0.2502   -0.0004
   -0.0004    0.0510


fk =

    0.0912
```

```
gk =

    0.3487
   -1.7434

------- Iteration 3 ------
STEP 2

dk =

   -0.0879
    0.0891


ak =

    0.9801


dtk =

   -0.0862
    0.0874

STEP 3
Norm of delta is 0.12 and epsi is 1.000000e-06
STEP 4

gk_new =

    0.0039
    0.0039


gmk =

   -0.3447
    1.7473


D =

    0.1824


sg =

   -0.0870
    0.0893


sw1 =
```

```
    0.0074   -0.0075
   -0.0075    0.0076


sw2 =

    0.0075   -0.0076
   -0.0077    0.0078


Sk =

    0.2503    0.0001
    0.0001    0.0500


fk =

   2.3119e-06


gk =

    0.0039
    0.0039

------- Iteration 4 ------
STEP 2

dk =

   1.0e-03 *

   -0.9827
   -0.1965


ak =

    0.9988


dtk =

   1.0e-03 *

   -0.9815
   -0.1963

STEP 3
Norm of delta is 0.00 and epsi is 1.000000e-06
STEP 4

gk_new =
```

```
   1.0e-07 *

   -0.1104
    0.5521


gmk =

   -0.0039
   -0.0039


D =

   4.6239e-06


sg =

   1.0e-03 *

   -0.9827
   -0.1965


sw1 =

   1.0e-06 *

    0.9633    0.1927
    0.1927    0.0385


sw2 =

   1.0e-06 *

    0.9645    0.1929
    0.1929    0.0386


Sk =

    0.2500   -0.0000
   -0.0000    0.0500


fk =

   9.1441e-17


gk =
```

```
   1.0e-07 *

   -0.1104
    0.5521

------- Iteration 5 ------
STEP 2

dk =

   1.0e-08 *

    0.2760
   -0.2760


ak =

     1


dtk =

   1.0e-08 *

    0.2760
   -0.2760

STEP 3
Norm of delta is 0.00 and epsi is 1.000000e-06
solution point:

xs =

   1.0e-16 *

   0.873078308755502
  -0.873093036706309

objective function at the solution point:

fs =

     9.147445973889177e-32

number of iterations at convergence:

k =

     5
```

Using Gauss-Newton

```
gauss_newton('funcNet1','gradNet1','jacobNet1',[1; -1],1e-3);
```

```
Program gauss_newton.m
------- ITERATION 1 ------
STEP 1

xk =

     1
    -1

STEP 2

F_k =

    12

STEP 3

gk =

     4
   -20


Jk =

    1.4142         0
         0    3.1623


Hk =

    4.0000         0
         0   20.0000

STEP 4

dk =

   -1.0000
    1.0000

STEP 5

ak =

     1

STEP 6
```

```
adk =

   -1.0000
    1.0000


er =

    1.4142

STEP 6

xk =

   1.0e-12 *

    0.2502
   -0.0501


F_k1 =

   1.5032e-25

------- ITERATION 2 ------
STEP 3

gk =

   1.0e-11 *

    0.1001
   -0.1001


Jk =

    1.4142         0
         0    3.1623


Hk =

    4.0000         0
         0   20.0000

STEP 4

dk =

   1.0e-12 *

   -0.2502
```

```
    0.0501

STEP 5

ak =

     1


adk =

   1.0e-12 *

   -0.2502
    0.0501


er =

    12

STEP 6

xk =

   1.0e-25 *

    0.6260
   -0.0251


F_k1 =

   7.9013e-51

------- ITERATION 3 ------
STEP 3

gk =

   1.0e-24 *

    0.2504
   -0.0501


Jk =

    1.4142         0
         0    3.1623


Hk =
```

```
    4.0000         0
         0   20.0000

STEP 4

dk =

   1.0e-25 *

   -0.6260
    0.0251

STEP 5

ak =

     1


adk =

   1.0e-25 *

   -0.6260
    0.0251


er =

   1.5032e-25

Solution point:

xs =

   1.0e-37 *

   0.156694315319573
  -0.001255563424035

Objective function at the solution point:

fs =

     4.912198130205698e-76

Number of iterations performed:

k =

     3
```

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